Developments in Compact Hg Microwave Ion Clocks for Space Operation

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We have recently completed a small breadboard Hg Ion clock with frequency stability 10^{-15} at one-day averaging time interval using Hg trapping technology that has shown stabilities in the low 10^{-16} range.

A 1 kg engineering model clock physics package is currently being fabricated with short-term frequency stability competitive with ground based hydrogen masers and long-term stability 10-100 times better than current Rubidium space clocks. Challenges in miniaturizing the ultra-stable clock will be outlined.

Several novel features are developed for long term reliability including the first use of a sealed tube approach to the Ion-Clock vacuum system. Ion trapping architectures that increase clock short-term stability and also shorten the local oscillator frequency tracking response time will be described.

We will discuss a novel line acquisition method where signal measurements at 3 points on the curve are used to determine the line center, ion signal size and light level from the lamp. This method is similar to curve-fitting algorithms and allows microwave power optimization for long term operation. This also provides the means for re-acquisition of frequency lock following a local oscillator frequency hop, with much less than a nanosecond timekeeping error.

We will also discuss novel microwave-rf transitions in Hg that may be very useful in reducing the level of magnetic shielding required for ultra stable operation. This could be important for further reducing the mass of a small Hg ion clock for space and ground operation since magnetic shields are the largest single contributor to the instrument mass budget.